Chapter 6

BUS TRANSIT

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This chapter presents elements of planning and operations for urban fixed-route bus transit system: Although rail and paratransit modes have been receiving increased attention, conventional fixed-route bus system are the most prevalent form of public transportation in the United States. The relative importance of fixed-route bu systems in terms of equipment and ridership for American Public Transit Association (APTA) member trans systems is shown in Table 6-1.

COMPARISON BETWEEN RAIL AND BUS SYSTEMS

The advantages of fixed-route bus systems compared with rail systems include:

• Relative ease of adjustment to meet changing travel patterns.

• Comparatively low capital costs.

. Relatively short time required to inaugurate or expand systems.

• A proven, relatively trouble free technology.

• Ease of bypassing barriers (accidents, fires, and the like) to the normal route.

TABLE **6-1**

Transit Equipment and Ridership

(APIA Members)

Mode	Active Vehicles 1988	Passenger-Miles (millions)1988
Motor bus (fixed route)	60,388	21,322
Demand responsive	18,190	601
Heavy rail	10,539	11,365
Commuter railroad	4,649	6,941
Vanpool	940	a
Light rail	831	471
Trolleybus	710	211
Automated guideway	99	a
Ferryboat	88	274
Cable car	44	a
Inclined plane	10	a
Aerial tramway	2	a
Total	96,490	41,377

aThe total combined passenger-miles for vanpool, automated guideway, cable car, inclined plane, and aerial tramway is 182 million.

Source: American Public Transit Association, *Transit Fact Book*, 1989 ed. (Washington, D.C.: American Public Transit Association, 1989), pp. 10-12.

Disadvantages of bus transit compared with rail, which become increasingly important in larger urban areas, include

- Lower capacity in high-volume travel corridors.
- Limited ability to reduce labor cost in high-volume corridors.
- Susceptibility to delays from other vehicles, except where exclusive bus or HOV facilities are provided.
- Less visibility of the route network (compared with rail), frequently resulting in less public awareness an understanding of available service and coverage.

In larger cities with dense and heavily used rail networks, buses are necessary to supplement rail routes and to feed into rail terminals. In 1989, for example, the New York City Transit Authority operated 6469 heavy rail cars and 4540, buses and the Chicago Transit Authority operated 1217 heavy rail cars and 2218 buses.[1]

Even with the resurgence of interest in rail systems in many U.S. cities (see Chaps. 5 and 11) and the expanded emphasis on paratransit operations (see Chaps. 7 and 21), fixed-route bus networks will continue to provide an essential role within the family of available transit technologies.

TYPES OF BUSES

Transit buses are classified into three types: standard, minibuses, and high capacity. Most transit buse purchased prior to 1980 in the United States were manufactured in this country. More recently the production c buses (as with rail cars and automobiles) has become multinational. United States law requires that any vehicl purchase that entails even the partial use of federal funds must contain a certain minimum percentage of domesti wages and materials. Accordingly, to meet this requirement, non-U.S. manufacturers have established U.S. assembl plants and use U.S.-made components. As of 1989, the inventory of active transit buses in the United States include the following top five manufacturers, by percentage of the active fleet: General Motors Corporation (35.7% Flexible (24.1%), Neoplan U.S A. Corporation (6.9%), AM General Corporation (4.4%), and M A.N. Truck and Bu Corporation (4.1%).[2]

STANDARD BUSES

The manufacturers of standard-size buses generally produce 35- and 40-ft (11- and 12- m)-long vehicle: Depending on seating arrangements, a 35-ft-long bus typically seats 40 to 45 passengers, whereas a 40-ft-lon vehicle typically seats 47 to 53 passengers. The buses may be either 96 in (2.4 m) or 102 in (2.6 m) wide. The wide buses provide for either wider, more comfortable seats or wider aisles. Recently, more attention has been devoted t upgrading standard bus design by providing lower floors, wider doors, wheelchair lifts or ramps, and other feature designed to make them more accessible to the elderly and handicapped.

MINIBUSES

Minibuses are produced by a large number of American and foreign manufacturers. The configurations var widely, and there continues to be a considerable degree of experimentation. Proliferation of models, mostly produce in small quantities, has been influenced by the interest and concern over service to the elderly and handicappe demand- responsive services, and service to rural and low-density areas. (See also Chaps. 14 and 21.)

A common misconception is that minibuses are cheaper to operate than standard size buses in fixed-route service. The largest single item of expense in bus operations is the driver's wage, which usually does not vary regardless of bus size. There is very little difference in fuel costs. Although the initial cost of a minibus may be lower, this is offset by a shorter life span. Thus, the operating costs of standard-size and minibuses are nearly the same. If only one trip per day requires standard-size seating capacities, it would be cheaper to operate a larger bus all day with many empty seats during most of the day than to operate a second minibus for the peak trip. Nevertheless, minibuses play important roles where volumes are always low and where maneuverability is paramount, as in many dial-a-ride or rural operations.

HIGH-CAPACITY BUSES

The United States has turned increasingly to the use of high-capacity buses, long used in Europe and elsewhere. The high-capacity bus, despite its higher initial cost, is frequently attractive economically on high-density routes because of savings in labor costs. The two basic types are the double-decker bus and the articulated (bending) bus.

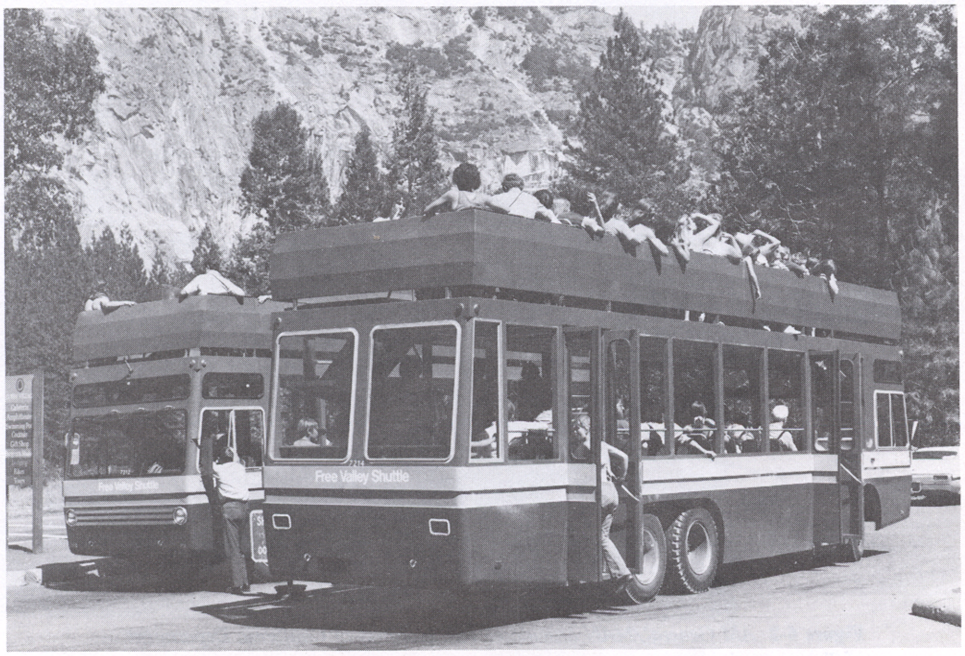

Figure 6-1 *Double-decker, gas-powered tourist bus in Yosemite National Park. Such buses are used in areas not open to autos. (courtesy of California Department of Transportation)*

The double-decker bus, although still popular in a number of European cities, particularly in Britain and the British Commonwealth countries, is actually less prevalent now in the United States than it was many years ago when they were used in New York City and elsewhere. The Southern California Rapid Transit District still has 18 Neoplan double-deckers (each seating 82 passengers) in its active fleet, and the University Transport System of Davis, California, uses seven antique double-deckers imported from London. In addition, the San Francisco Muni has been conducting a small-scale experiment with double-deckers prompted by the difficulties they have had with articulated buses in crowded traffic. Nevertheless, it appears that the use of double-decker buses in regular transit service in the United States is near extinction. One of the main disadvantages of double-decker buses is the slower loading and unloading of passengers because of the awkward and slow access to the upper deck.

On the other hand, many U.S. transit operators have been ordering articulated buses. Typically, they are 50 to 60 ft (15 to 18 m) long and seat 66 to 72 passengers. With at least two, frequently three, and sometimes four extra-wide doors, loading and unloading is much faster than with double-decker buses. Of course, greater street space is required than for a double-decker bus accommodating the same or a larger number of passengers.

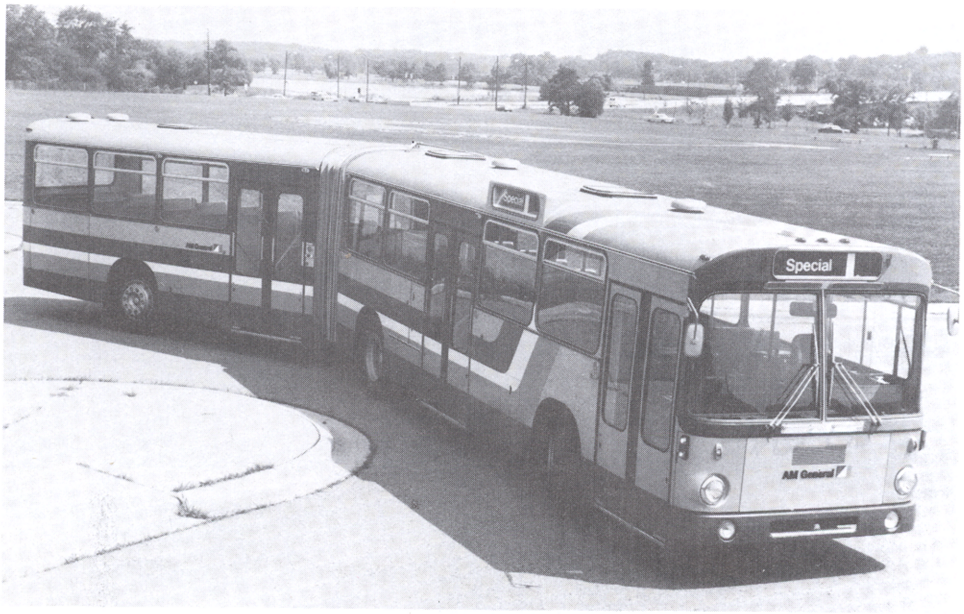

Figure 6-2 *AM General/MAN articulated bus. (courtesy of California Department of Transportation)*

Specialized Categories

In addition to classifying transit buses according to size, some specialized categories should also be mentioned.

Trolleybuses. Early trolleybuses are discussed in Chap. 1. Modern trolleybuses are manufactured by several of the same companies that make motor buses and are available in standard-size and articulated versions. They should usually be considered as an alternative to buses powered by fossil fuels only on routes with high passenger volumes supporting frequent service that can justify the added capital expense of the electric power-distribution system. An added incentive for their use in cities such as Seattle and San Francisco has been their superior performance in climbing steep hills.

Dual-powered buses. In 1990, Seattle completed and opened a 1.3-mile transit tunnel under the central business district to provide added transit capacity to a severely constrained street system. Originally, it was planned for this tunnel to be used by diesel buses. Further study revealed that it would be extremely difficult to provide an adequate ventilation system to remove the exhaust fumes, so it was decided that the tunnel would require the use of electric-powered vehicles. Many long suburban transit routes, most operating for considerable distances on freeways, feed into the downtown tunnel. It is not feasible to electrify the outer portion of all these routes. Therefore, Seattle chose to place an order with Breda of Italy for more than 200 specially designed dual-powered buses, which operate by diesel power for the major portion of each trip and then switch to electric power for the trip through the tunnel.

Figure 6-3 *Seattle dual-powered bus—trolleybus in tunnel and diesel electric on surface. (courtesy of Harre W. Demoro Collection)*

Trolley replicas. Buses designed to resemble trolleys or trams are appearing in a growing number of tourist areas, central business districts, and specialized shopping areas. Since they operate on rubber tires and have no trolley pole, the use of the word

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trolley is really a misnomer. They are usually built with wood exteriors to resemble antique streetcars to give them a nostalgic appeal.

FIXED FACILITIES

Division Facilities

All bus systems require an administrative office and one or more storage, servicing, and maintenance bases. The administrative offices may or may not be in conjunction with a maintenance facility. Routine servicing includes fueling, removal of farebox receipts, interior cleaning, and exterior washing. Other maintenance functions include engine overhauls, repair of malfunctioning equipment, body painting, and repair of damaged seats and other interior furnishings. The dispatching function at each storage and servicing base (often called a *division* by transit operators) involves assigning buses and drivers to the schedules on each route assigned to that base.

A typical division in a medium-size transit system may support 200 to 300 buses. Above that number of buses, the savings from centralization of functions and avoidance of duplication should be measured against the potential operating savings of an additional division through reduction of *deadhead* bus mileage between the storage area and the start of in-service trips. There is, of course, no magic formula; each geographical and scheduling situation is unique. In any event, all service facilities should be carefully placed in relationship to the transit route network so as to minimize deadheading. A middle ground between centralization and decentralization would be to provide routine servicing at all divisions, but to concentrate the other maintenance functions requiring specialized equipment, personnel, and parts inventories at only certain division locations.

Park and Ride

Park-and-ride lots are becoming an increasingly important aspect of bus transit systems in a number of cities. They provide convenient access to transit via auto or bicycle for those persons who do not live within convenient walking distance of a bus line. By concentrating boardings at a single point, a more frequent level of service can be supported. Most park-and-ride lots are used primarily by commuters headed for central business districts or other major employment centers. By far the most successful lots are the ones that are large enough to support frequent bus departures during the peak hours. Usually, the best locations are near freeways where fast peak-period express service can be provided to employment centers.

In many cases, buses may perform normal residential neighborhood pickup, making their last stop at a park-and-ride lot, and then operate in the express mode. In this style of operation, several pickup routes could converge at one park-and-ride lot and support very frequent and attractive service at that location. It is desirable to locate park-and-ride lots on an al day bus route (not necessarily express) in order that commuters not be isolated from their autos durin noncommuting hours.

BUSWAYS

Some cities, such as Pittsburgh and Ottawa (Canada), have constructed and continue to operate busways fo the exclusive use of express bus service. In other cases, such as the El Monte busway in Los Angeles and Shirle busway in suburban Washington, D.C., facilities originally constructed as exclusive busways have been downgrade to high-occupancy vehicle (HOV) lanes by allowing joint use of the facility by carpools. Numerous other cities, suc as Houston, are constructing new HOV lanes to speed express bus service, but since carpools are also allowed o these facilities, technically they should not be called busways.3,4 4

COMMUNICATIONS

There has been rapid growth in the capabilities and reliability of bus communications systems since 197(Initially, only supervisor's cars had two-way voice radio contact with the central dispatcher; now almost all buse have two-way voice radios of increasing sophistication. Drivers can quickly report traffic delays, accidents, i passengers, and other incidents, and dispatchers can quickly reach drivers to issue instructions in cases of emergenc or service disruption. Most systems also have "silent alarms" so that the driver can alert the dispatcher who can i turn contact police in case such assistance is needed. Voice communication will probably be gradually supplemente and in some cases replaced by automatic data communication. Data communication reduces transmission time an can deal with more information. Examples of newly developing data communication include automatic vehicl location systems (useful in conjunction with the silent alarm system and for more complete and continuou monitoring of schedule adherence) and automatic passenger counting. The availability of more data concernin passenger boardings and alightings at each bus stop and the number of persons on board each bus between each sto will enable planning and scheduling departments to do their jobs much more effectively.5

USER AMENITIES

Other facilities in an all-bus system frequently include passenger waiting shelters or stations and bus-sto signs. An attractive marketing image should be conveyed by user amenities. In addition, signs should be accurat useful, easy to read, and consistent in format.

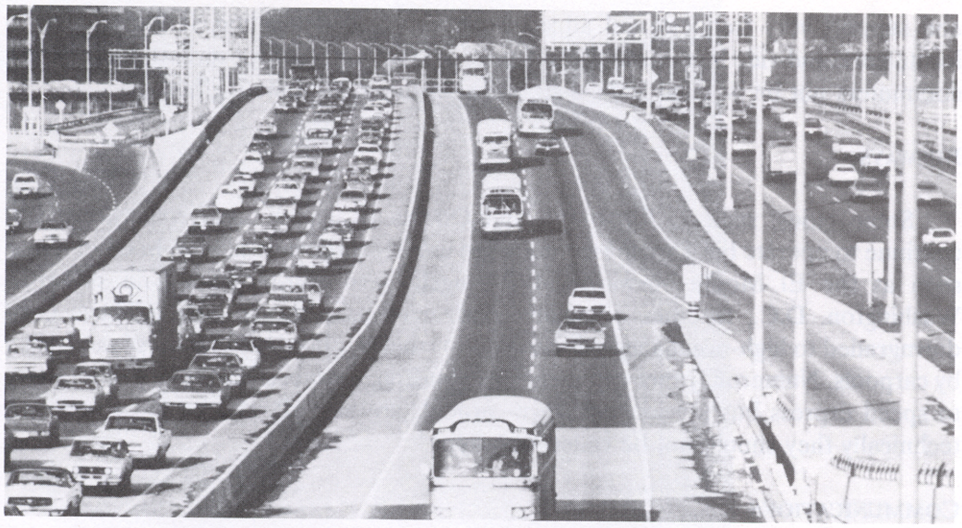

Figure 6-4 *Reversible bus- and carpool lanes on Shirley Highway in Virginia. (courtesy of Federal Highway Administration)*

Figure 6-5 *San Bernardino Busway—El Monte Station. Present eastern terminal of busway, showing station and parking. (courtesy of California Department of Transportation)*

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TYPES OF BUS NETWORKS

Perhaps the most important factor in the quality and adequacy of service provided by a fixed-route bu system is the design of the network of routes. This section describes the major types of bus networks; in actua practice, most urban bus systems will employ some attributes of several network types.

RADIAL PATTERNS

In older cities, where most major activities were concentrated in the downtown area, streetcar lines typicall fanned out in a radial pattern from the central business district (CBD) into the suburbs (Fig. 6-6). Often, whe streetcars were phased out, buses followed the same routes although usually with some adjustments. As new suburb were added, the routes were extended. Although crosstown lines were often added, some local transit systems sti follow a basic radial pattern.

Radial patterns can continue to serve work trips to downtown effectively as long as there is a reasonabl concentration of employment there. But if downtown commercial activities, such as shopping, are relocated to th suburbs, this type of transit network may not have convenient access to the new locations. Instead of being able, fo example, to go shopping downtown from every neighborhood, access to a new shopping center by transit is possibl only if you happen to live in the same transit corridor.

Many urban activities have become decentralized, including employment, medical facilities, colleg campuses, and entertainment. These profound changes in land use in the typical American city have made it difficu for a radially oriented bus network to provide adequate service for most urban trips. Clearly, other approaches mus be considered.

GRID TYPE NETWORKS

Grid-type bus route networks (Fig. 6-7) feature relatively straight, parallel routes spaced at regular interva and crossed by a second group of routes with similar characteristics. They generally require a minimum o geographic or topographic barriers and an evenly spaced network of arterial streets suitable for bus operations.

An example of a grid-type network can be found in Chicago, where surface bus operations of the Chicag Transit Authority follow a grid pattern but interconnect with rail rapid transit and commuter railroad lines tha follow a radial pattern. Other examples of a grid bus network are those operated by the Southern California Rapi Transit District in Los Angeles and by the Toronto Transit Commission in Canada.

A major advantage of a grid-type system for an area that has widely scattered activity centers is that rider can get from almost anyplace to almost anyplace else with one transfer, without having to travel back through central point such as the CBD.

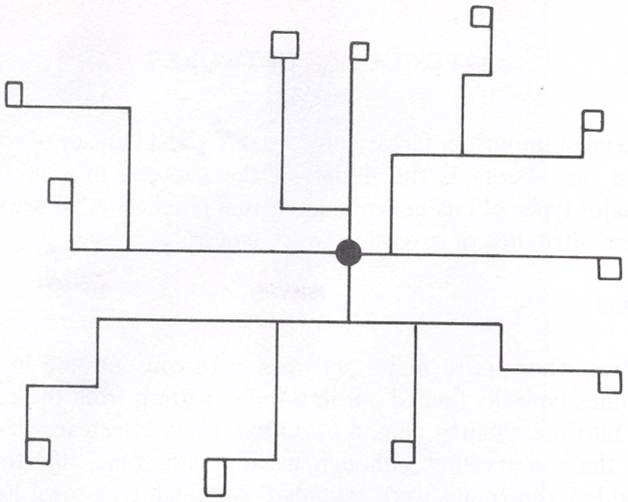

Figure 6-6 *Radial bus route network.*

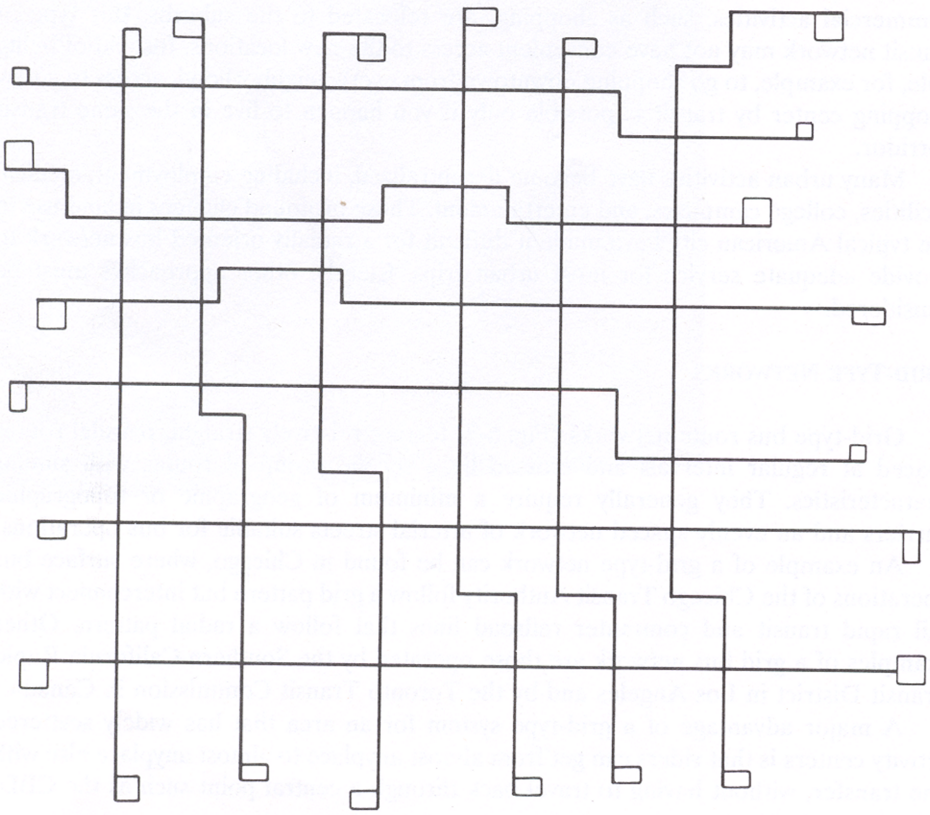

Figure 6-7 *Grid bus route network.*

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Another advantage is the relative simplicity of the system. The major disadvantage of the grid system is that in orde to get from anyplace to almost anyplace else, a transfer is usually necessary. For example, for a high volume of trip between two points diagonal to the grid, all passengers would be required to make a transfer. In another kind c network, the high volume of trips between two points might be accommodated by more direct routing.

For a grid system to work well, frequent service should be furnished on almost every line: headways should b every 15 or 20 min, or even less. A grid system will not work well with half-hour headways because it i mathematically impossible to schedule more than a few key locations for convenient transfer connections. Th remaining locations will involve long waits for transfers. (The theoretical average wait on a grid system is half th headway.) A successful grid system depends on random connections and frequent headways. If population density c ridership is low and wil1 not support frequent headways, it is doubtful that a grid system will be very successful.

RADIAL CRISSCROSS

One way to obtain certain characteristics of a grid system and still maintain the benefits of a radial system is t crisscross the lines and provide additional points where lines converge, such as at shopping centers or colleges. I Fig. 6-8, all four lines operate directly from the central business district to an outlying regional shopping center. B crisscrossing, the lines also provide grid-type transfer opportunities to intermediate locations. Under a pure gri system, there would be no direct service from the CBD to the shopping center.

TRUNK LINE WITH FEEDERS

The trunk line with feeders system (Fig. 6-9) is based on a strong major transit artery, either bus or rail, serving major travel corridor. Because of topography, geographical barriers, street patterns, or other reasons, it is preferabl to provide feeder service to the major trunk line rather than to run bus lines all the way to the ultimate majc destination. A major disadvantage of this system is the necessity for most passengers to change vehicles. A advantage is that a system of feeders can support a higher level of service on the trunk line than if it were supporte only by passengers walking to stops.

Examples of trunk lines with feeders include certain bus—rail connections of the transit systems in Edmonto (Canada), Atlanta (Georgia), and Sacramento (California); connections between Alameda—Contra Costa Trans buses and Bay Area Rapid Transit (BART) in the San Francisco Bay area; low-density neighborhood shuttle-bu connections to main bus lines in many cities; and the Postal bus system in Switzerland, which feeds into, but i prohibited by law from paralleling, the Swiss National Railways.

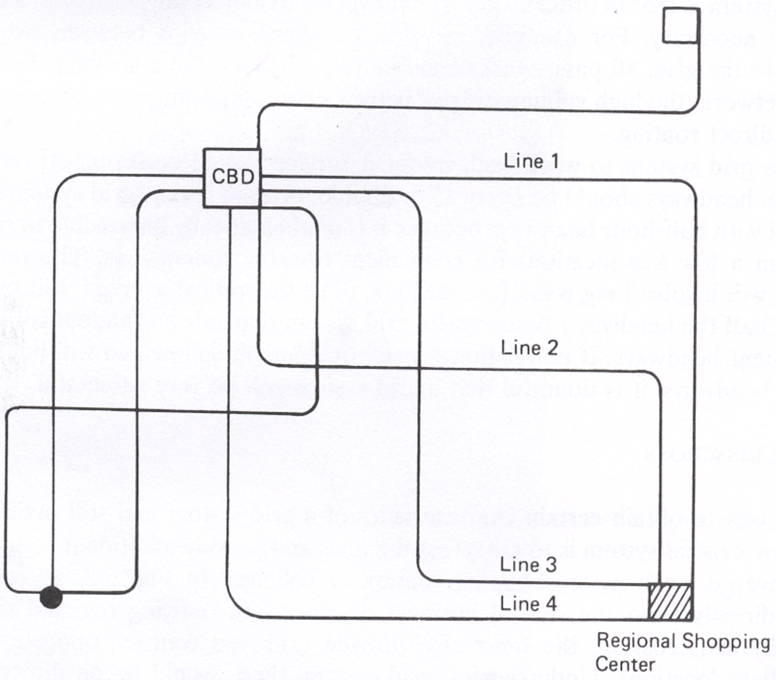

Figure 6-8 *Radial crisscross bus route network.*

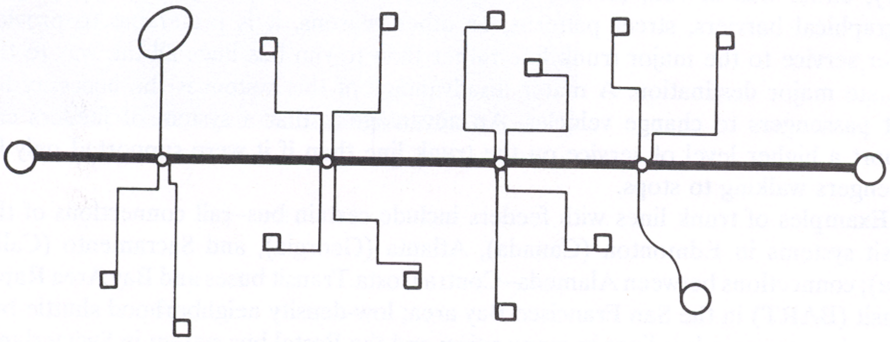

Figure 6-9 *Trunk line with feeders.*

TIMED TRANSFER NETWORKS

Timed transfer networks require an unusually high degree of coordination between route planning an scheduling. Most transportation networks have certain locations where vehicles are scheduled to meet, or at leas intersect in timed sequence, to allow interchange of passengers. In a timed transfer network, entire systems or majc segments of systems are laid out to facilitate such transfers. At a limited number of locations, bus lines ma converge at passenger interchange points or *timed transfer focal points,* which are frequently located at regiona shopping centers or other major activity centers. All lines serving a given interchange point operate at the sam frequency and are scheduled to arrive at about the same time and to leave at the same time, following a layove period that allows passengers to change buses. The advantages to the passenger include not having to go downtow for transfers, as in a radial system, or having to rely on random transfers, perhaps with long waits at inhospitabl street corners, as in the grid system. With the timed transfer network, most transfers can be made within a sho period of time and under favorable conditions.

Edmonton was one of the first cities in North America to establish a timed transfer network on a large scal Other North American cities that are establishing or expanding timed transfer service include Portland, Oregon, an Sacramento, California.

A timed transfer network can be extremely complicated to design and requires very careful planning. Among th problems that must be resolved are:

1. Possible differences in running time between several routes operating between the same pair of focal points.
2. Scheduling conflicts between the demands of focal points and those of intermediate points, such as class-brea times at school and colleges.
3. Differences in running times by time of day due to traffic congestion.
4. Differences in passenger volumes by time of day on some routes serving timed transfer focal points, makin evenly spaced headways unsuitable.
5. Unsuitable relationships between running times and frequency of service, causing wasted vehicle and operatc hours.
6. One or more lines serving a focal point being subject to fluctuating and unpredictable traffic delays, resulting i either missed connections or, if it is the policy for buses to wait for connections, one delayed bus causing an entir group of buses to be delayed.

BRANCHES AND LOOPS

As the service area of any transit system expands, it becomes difficult to provide adequate route coverage to remote areas. One approach to serving the outermost fringes of a radial network is to branch the lines. For example, a route may have a 15-min frequency on the trunk portion, a 30-min frequency on each of two branches, and an hourly frequency on each of four subbranches.

One way to cover more territory without reducing frequency is to add a loop. The basic trade-off to passengers i the increased frequency of service made possible by the loop as compared with the increased riding time. A ride living near the beginning of a loop has a longer ride inbound, and one living near the end of a loop has a longer rid outbound. If layover or recovery time is included in the schedule for the loop, the situation becomes even mor undesirable in terms of passenger service. Therefore, if possible, all or most recovery time should be scheduled at th end of the line opposite from the loop, and lines with loops at both ends should be avoided. As a general rule, loop are more desirable with longer headways; branches, with shorter headways.

THROUGH ROUTING

Some bus systems bring all buses from all neighborhoods to downtown, loop them around, and send them bacl This policy results in a lot of turning movements downtown, but each line can be operated as an individual entity Combined routing or *through routing* can reduce mileage, turning movements, congestion, and transferring.

In order to through-route, it is necessary to balance the characteristics of the combined lines so that the frequenc and hours of service needed on each are the same. Obviously, it is not feasible to through-route a line on a 10-mi headway with one on a 15-min headway. It is possible (although not ideal) to through-route a line on a 30-mi headway with another on a 15-min headway and have alternate buses turn back.

Another consideration in through routing is the relationship between headways and the lengths of the lines an running times. For example, consider a hypothetical single line that would take 62 min to run a round trip withou recovery time, with passenger loadings justifying about a half-hour headway. Allowing for layover, it is not desirabl to run two buses at 35- or 37-min headways, for reasons that will be outlined later. Running three buses at a 30-mi headway would result in excessive and wasteful layover. One solution to the problem would be to through-rout with another line that takes somewhat less than 1 h for a round trip so that four buses could maintain an even 30-mi headway on the through-route combination.

DETAILED FACTORS IN BUS ROUTE PLANNING

The following sections are intended to serve as a checklist and brief description of details that should be considered when route planning.

GOALS AND OBJECTIVES

The goals and objectives, including service standards and level-of-service criteria, adopted by the transit agency should be the starting point for route planning. For example, what policy has bee adopted with regard to the degree of effort that should be directed toward serving the needs of the transit-depende population versus the degree of effort devoted to serving the needs of commuters, who are apt to be choice riders An emphasis on the former will be more directed toward meeting the social needs of the community, whereas a emphasis on the latter would undoubtedly mean greater concern for goals such as energy conservation and reductio of congestion and air pollution.

DEMOGRAPHIC DATA

Maps of key demographic factors by census tract or other convenient subarea should be prepared for the trans service area as a basic reference in laying out the route network. Examples would include the percentage c population without cars, percentage of population over age 65, average income, and residence location of colleg students. These data give useful insight into the "home" end of home-based trips.

LAND USE

Major activity centers in the community should be mapped, including major shopping centers, major employer schools and colleges, and hospitals and clinics. A convenient way to accomplish this is to indicate a precise locatio for each activity center, with the size of the symbol proportional to the number of person-trips generated per day This precise mapping is far more useful in transit-route planning than a generalized level of activity by zone Precise mapping is necessary because bus routes must travel within a short distance of the entrance to these activit centers if the bus system is to be used for access.

Close liaison must be maintained with local and regional planning agencies to ascertain land-use plannin policies as they relate to the layout of future transit routes. Increasingly, planning agencies will be called on t pursue such policies as the clustering of activities that facilitate transit use.

Residential density must be carefully noted. The higher the density is, the more closely spaced and/or mor frequent the level of transit service that can be supported. It is useful to arrange with local planning commissions t obtain copies of proposed subdivision plats in order to influence possible transit amenities and to learn in advance c areas where route extensions may be needed in the near future.

STREET STANDARDS AND SAFETY CONSIDERATIONS

If existing streets do not meet minimum standards of continuity, width, and loadcarrying capacity, routin compromises will be required. The transit operating agency should have a role in the decision-making proces regarding street layout and design when new areas are developed or older areas renovated.

Safety factors include the avoidance of potentially hazardous turns and the availability of traffic signals and stop-sign protection. For example, left-turn entries into busy arterials should be made only at intersections with traffic signals.

PEDESTRIAN ACCESS

A commonly used rule of thumb is that transit patrons should not be required to walk more than 0.25 mi (0.4 km) to reach the nearest bus stop. This would result in parallel routes being spaced about 0.5 mi apart. In low-density suburbs, this goal might have to be compromised if there is an insufficient density of housing to support a close network of lines.

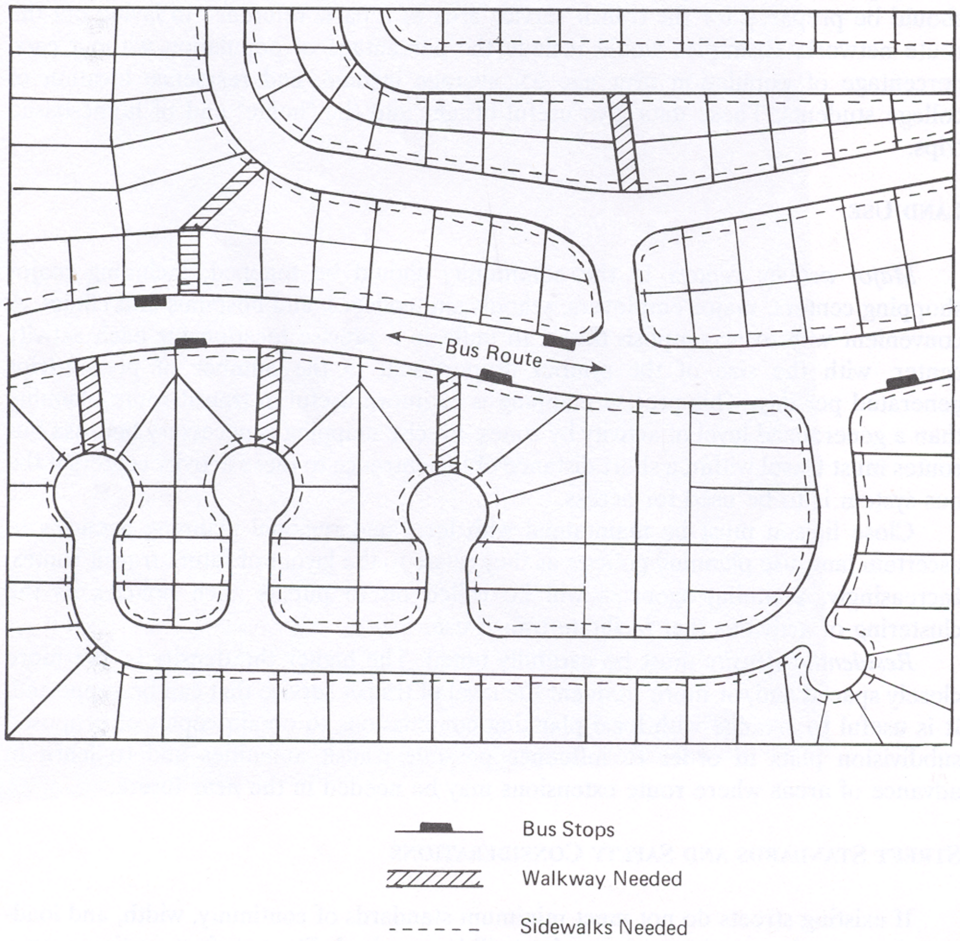

Figure 6-10 *Subdivision plan showing pedestrian access.*

Pedestrian access is becoming an increasingly important factor, particularly in newer subdivisions designed wit curvilinear streets to discourage through traffic (Fig. 6-10). Increasingly, transit-route planners are faced wit situations where routes might be within the standard 0.25 mi of each residence "as the crow flies." The shortest pat from some houses to the nearest bus stop, however, might actually be much longer through the maze of streets th must be followed. The transit operating agency should be sure local planning agencies are constantly aware of th need for convenient and direct pedestrian access to the streets where bus routes are located.

FINANCING CONSTRAINTS

Route planning must be done not only under the constraint of the total budget, but also within the limits alternative routings that would produce the greatest revenue per mile. In some cases, regional operators may als have formula restrictions regarding allocation of levels of service among various jurisdictions served. (See als Chap. 15.)

MARKETING STRATEGY

Included are considerations as to which market or neighborhood or line would be easiest to sell. Depending upo the circumstances in a particular community, it might be an important factor to concentrate initially on lines mos likely to quickly succeed in terms of increased patronage in order to be able to point to success as a catalyst f future success.

TRAVEL PATTERNS

Overall travel patterns within the community, most of which are undoubtedly by auto, are important. Howeve methods of analyzing these patterns for purposes of designing street and highway networks, frequently usin computer modeling as a tool, are not always helpful for bus route planning. Travel patterns are typically aggregate by analysis zones, which may be too large to help in the detailed planning necessary in laying out bus routes. Th broad travel patterns should, of course, be analyzed and understood in determining general corridors and major trav flows, but they are only one factor. As for computer modeling of bus networks, one must first lay out a network series of networks to be tested by the model in order to lay out a service network with some chance of success. I this process, the other factors listed take on prime importance.

Care should be taken in tinkering with long-established lines with entrenched transit ridership patterns. In th hope of gaining 100 passengers by rerouting a line, you could lose 500 already riding the existing service.

CONVENIENCE, SIMPLICITY AND CLARITY

The various lines of a transit-route network cannot be analyzed independently. Each must be thought of in term of how it relates to others in the network. Provision of safe, convenient, and pleasant locations for transfers is a especially important factor.

The objectives of simplicity and clarity to the user should not be overlooked in an effort to consider all the othe factors. An intricate, sophisticated network that works on paper will be a failure if it attracts few riders because it i too complex for the public to understand.

SCHEDULING CONSIDERATIONS

Factors such as headways, running times, number of vehicles, loops, and short turns should be taken int consideration. If the route planner has an option of extending either of two routes into a new subdivision, schedulin considerations might be the deciding factor regarding which of the routes should be extended.

POLITICAL CONSIDERATIONS

The degree of public support for alternative proposals and the level of requests and petitions for alternativ transit improvements must always be considered. Transit needs usually do not match up closely with city and count boundary lines. It is not unusual for a single transit line to pass through several political jurisdictions. Depending o financing arrangements and decision-making authority and procedures, reaching agreement among all the concerne parties may be time consuming and difficult.

SCHEDULING

POLICY HEADWAYS

The frequency of service on a given route is usually based either on *policy headway*, a formally adopted or unstate policy regarding the minimum level of service to be provided, or on the frequency of service necessary to handle th passenger loads, or on some combination of the two. Policy headway (typically every 60, 30, 20, or 15 min) is mor apt to be used during nonpeak hours, and passenger loads are used during peak hours. Since there may b considerable unused midday capacity on lines operating policy headways, one could argue that costs could be cut b reducing service. During peak hours and on more heavily traveled lines, however, the frequency of service is mor apt to be a function of passenger volume. Since additional drivers and buses are usually required to handle peak-hour loadings, the out-of-pocket costs of providing a higher level o partially used midday service are less than they would otherwise be.

It is desirable to have headways longer than 10 min to be evenly divisible into 60 (60, 30, 20, 15, 12, 10). Simila headways are necessary to facilitate transfer connections, with or without a full-scale timed transfer networl Departure times of any headway divisible into 60 repeat themselves each hour, and riders can more easily remembe them. It is much easier for a telephone information clerk to tell a caller that a bus "leaves at 10 and 40 minutes pas each hour" (30-min headway) than to have to say the bus "leaves at 9:10, 9:37, 10:04, 10:31, and 10:58" (27-mi headway). Also, it is important to coordinate schedules with class starting and ending times at local colleges, and th like, which are usually on a 1-h cycle.

For headways shorter than 10 min, these factors are relatively unimportant, since riders no longer tend to rely o timetables and are more likely to arrive at bus stops randomly.

LAYOVER OR R RECOVERY TIME

There are several reasons why layover time is scheduled at one or both ends of each line:

1. To give the driver a rest.
2. To maintain schedule reliability. Traffic conditions vary from day to day because of accidents, unusual congestion and so on. For any number of other reasons, the running time from one end of the line to the other may b different from one day to the next. It is necessary to have a time cushion to allow the bus to leave on time on th next trip.
3. To maintain reasonable headways. It is better practice to run a bus every 30 min than every 27 min, even if means the driver has 3 additional minutes of layover time each trip.

PEAK-TO-BASE RATIO

The peak-to-base ratio of a transit system is the ratio between the number of vehicles operated during the pea hour compared to the number scheduled during the midday or base period. Some systems with a high proportion o transit-dependent riders, who may use the system primarily for shopping or medical or social purposes, ca accommodate passenger volumes without adding additional buses during the rush hour. The peak-to- base ratio i such a case would be 1: 1.

As a system becomes successful in capturing home-to-work trips, additional buses must be added to handle th higher peak-hour volumes. These buses are less productive since they operate fewer hours per day. Even mor important, it becomes increasingly difficult, even with split shifts, to arrange a full day of productive work for a drivers. Many transit systems help fill part of the midday gap in demand for buses and drivers by scheduling service to schools (usually just after the morning commuter rush and just before th evening commuter rush), special midday shopper shuttles, and other services targeted to off-peak ridership markets.

STAGGERED WORK HOURS

One partial solution to the problem of equipment and driver utilization during peak travel hours is th encouragement of staggered work hours. To the degree that staggered work hours reduce traffic congestion an thereby increase speeds and schedule reliability, they, of course, benefit transit. For the staggered hours to hav significant impact on equipment utilization, however, the spread between the first and last starting and ending wor shifts must be great enough for *tripper* buses (buses used during peak hours only) to travel to the end of the line an return for second trips. As cities sprawl and bus lines get longer, this becomes increasingly difficult. More secon trips can be produced by deadheading some buses back nonstop in the low-volume direction, or by short-turnin alternate buses before the end of the line on high-frequency lines.

Surprisingly, staggered work hours even work to the detriment of transit in some circumstances. First, if th spread between work hours is great enough to allow a large number of second trips by tripper buses, then it become increasingly difficult to meet restrictions contained in most bus-driver labor contracts, which limit the sprea between the start of the first piece of work and the end of the last piece of work of split shifts.

Second, in some isolated low-density suburbs, there may be only one or two bus loads of commuters destined fo a given employment center. With standardized work hours, direct express bus service might be provided. Wit staggered work hours, either the bus schedules will not match work times, or extra half-empty buses would have t be operated to meet the additional shift-change times. (See also Chap. 12.)

FARE COLLECTION

FLAT FARES

Flat, or uniform, fares for the entire system have the advantages of simplicity, understandability, marketability, an ease of collection. The major disadvantages of flat fares are equity and forfeiture of potential revenues, particularl on longer trips. Fares differ by class of passenger: one of the requirements for U.S. transit systems to be eligible fo federal subsidies is that they charge not more than half the regular fare to elderly and handicapped persons durin nonpeak hours. Most systems also provide reduced rates for youth or school riders. Some systems charge highe fares during peak hours in recognition of the higher costs incurred in providing peak-hour service and as an incentive to those having the option to ride during nonpeak hours, thus tending to level demand.

Prior to 1970, 25 cents was a common flat fare. It had the advantage of being a single-coin fare that could also b paid by multiple coins. This factor became of increased importance when most transit systems, for security reason adopted an exact fare policy so drivers would no longer have to carry change. As inflation caused the 25-cent fare t be a thing of the past, tokens or tickets worth odd amounts, such as 35 cents or 65 cents, took on added importanc for customer convenience, and additional transit system energies had to be devoted to providing convenient sale outlets for them. As single flat fares approached or exceeded a dollar, an added complication has been that fareboxe were not designed to accept paper money, and major changes in the design of fareboxes and methods of handlin fare receipts were required. Many transit systems had to go to the considerable expense of replacing all the fareboxes, and handling, counting, and providing security for paper money has proved to be more expensive tha dealing only with coins.

ZONE FARES

Newer rail systems, such as BART and the Washington, D.C., Metro, have established fare-collection hardwar to make it possible to charge by the length of the ride, which is more equitable than a flat fare. Lacking, thus far, th necessary automated equipment, the closest that bus operators can come to charging according to the length of th ride is through use of a zone system, which is difficult to administer.

Traditionally, a zone system has consisted of one large central zone surrounded by several concentric oute zones. A basic fare (for example, 75 cents) is charged upon boarding, and additional zone charges (for example, 1 or 25 cents) are collected for each zone line crossed.

There are two basic methods of collecting the extra zone charges. The first relies on driver memory and work best in radial-type networks. It assumes that most inbound passengers have a destination in the central zone. Mos passengers on boarding inbound pay the full fare, including zone charges to the central zone. Any passenge intending to get off before crossing one or more zone lines would so inform the driver, who would collect the lesse fare and then be expected to see that the passenger gets off within the proper zone.

Outbound, the basic fare is collected upon boarding in the central zone, and once the first zone line is crosse zone surcharges are collected as passengers leave the bus. Passengers boarding in outer zones are issued receip noting their boarding point so that they are not charged for zone lines not crossed. Obviously, this system i cumbersome to drivers and passengers alike and very confusing.

Outbound in outer zones it is not possible to use the rear door for exit, as all leaving passengers must file past th farebox to deposit their zone surcharges. This slows down operating speeds. Having to pay twice on the same tri (with multiple coins) is also very inconvenient to passengers.

The other method of collecting zone charges is for passengers to pay the full fare upon boarding, with the drive issuing a receipt for any zone fares paid. The bus is stopped at each zone crossing, and the driver then passes throug the bus to collect zone receipts. This method is more workable in grid-type bus networks and eliminates the need fo the driver to remember which inbound passengers promised to get off before crossing zone lines. The rear door ma also be used for exit at all times. But the delays at zone crossings can be extensive.

Zone systems can be inequitable, too. Short trips crossing zone lines cost more than longer trips that may b entirely within one zone. Obviously, some technological breakthroughs are needed in bus fare-collection systems.

FARE -FREE ZONES

Several cities, including Pittsburgh (Pennsylvania), Seattle (Washington), and Portland (Oregon), have establishe fare-free zones within their central business districts. These zones were installed to facilitate circulation within th CBD and to reduce traffic congestion and have generally been considered successful. Operationally, they are mad possible by paying on entering the bus inbound and paying on exiting outbound. Loading and unloading is expedite in the CBD, since both front and rear doors may be used to either enter or leave the bus. But time is lost on th outbound trip, since after leaving the CBD, only the front door may be used and fare transactions may be involved.

TRANSFERS

Most bus systems issue transfers to passengers so that they may continue their journeys when a single bus lin does not serve both trip origin and destination. Usually, transfers are free, although some systems may charge a sma amount for them. Traditionally, transfers have had both a time limit and complex rules regarding acceptanc designed to reduce opportunities for riders to make a round trip on a single fare. Complex transfer acceptance rule tend to foster confrontations between drivers and passengers regarding their interpretation. Such rules are a legac from the years when public transportation was a profit-making enterprise and cheating with transfers was considere a drain on revenues.

With increased emphasis on transit as a public service, assuming increased public benefits with increased usag cheating with transfers has become less of an issue, and there is a trend toward liberalizing transfer rules. Anothe influence has undoubtedly been a desire to reduce the potential for unpleasant conflict between drivers an passengers over the interpretation of complex rules. In many systems, the use of transfers is now limited only b time, and passengers are permitted to make round trips if they can do so before the time limit expires.

FARE PREPAYMENT

In recent years, transit operators have given increased emphasis to fare prepayment plans, generally involvin passes good for unlimited riding during a given period, usually a month. Daily, weekly, and annual passes are als used. Several systems offer a youth pass good for the summer school/vacation season. From a marketing standpoin these passes encourage additional riding, eliminate the inconvenience of having to carry a pocketful of coins and th need for transfers, and emphasize the low monthly cost of transit riding compared with driving an automobile.

More systems, especially in tourist areas, are now offering day passes, good for one day of unlimited riding Sometimes these are available only for weekend riding; in other systems they are valid 7 days a week. In some case day passes are available from the bus driver in others they must be prepurchased at special limited location Vancouver, B.C., sells a particularly innovative day pass in the form of a "scratch-off”" cardboard ticket. They ar sold at all SkyTrain stations and at other retail locations. Users may purchase these tickets in advance, and the day c use need not be determined until the user scratches off the appropriate date on the ticket before the first use.

Such prepayment schemes also offer possibilities of payroll deduction and/or subsidization by employers wh desire to encourage transit use and thereby reduce parking needs. To the transit operator, they offer benefits such a reduced money-handling expenses and slightly improved cash flow by providing payment in advance. Balance against these advantages must be the costs of the pass-distribution system.

As transit systems strive to compete with the private automobile in whatever manner possible, the convenienc of fare prepayment systems compared to having to deposit multiple coins in the farebox and having to worry abou restrictive transfer rules takes on considerable importance.

SELF- SERVICE BARRIER-FREE FARE COLLECTION

Self-service fare collection systems have sometimes been called "honor" systems, but this is misnomer, becaus such systems rely on spot-checks by inspectors and the levying of fines for attempted fare evasion. They have bee used in both rail and bus applications in numerous European cities and, more recently, have been installed ver successfully in several newer North American light rail systems (Edmonton and Calgary, Canada; Portland, Orego and Sacramento, San Jose, San Diego, and Los Angeles—Long Beach, California). (See Chap. 5).

One large-scale North American experiment applied self-service fare methods to an entire bus network. In 198 the Tri-County Metropolitan Transportation District (Tri-Met) in the Portland, Oregon, area converted its entire bu network to self-service fare collection, with the financial assistance of an UMTA demonstration grant.6,7, Numerous unexpected difficulties were encountered. There were some problems with the fare collection equipme on the buses, but the major problem was an unaccep tably high fare-evasion rate. In 1984 the experiment was terminated and fare collection on buses reverted to the previous more traditional system. On the other hand, self-service fare collection methods were successfully introduced and continue to be used on the Portland light rail system.

It appears that on high-density transit routes, such as on the Portland light rail line, it is financially feasible to employ enough fare inspectors to keep the fare evasion rate to an acceptably low level. On a far-flung bus system, with many low-frequency, low-volume bus trips, it apparently is not feasible to do so.

Nevertheless, this experiment undoubtedly produced much useful information, and any bus operator contemplating innovations involving self-service fare collection techniques would be well advised to study the Portland experience carefully.

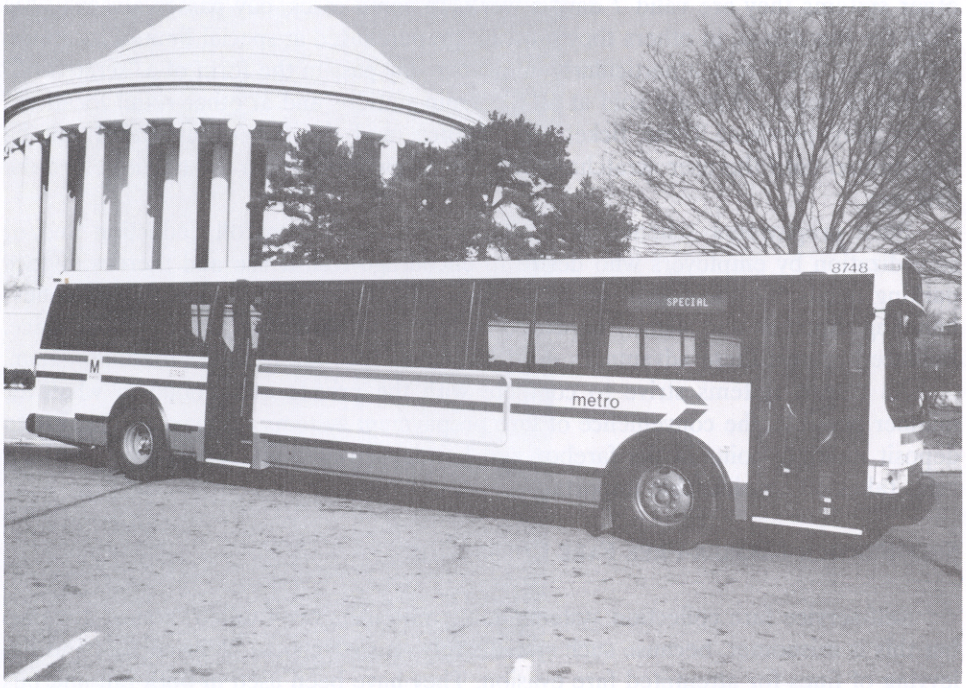

Figure 6-11 *WMATA Flxible bus at the Jefferson Memorial, Washington, D.C. (courtesy of Washington Metropolitan Area Transit Authority)*

SUMMARY

Conventional fixed-route bus systems are the most prevalent form of urban transit in the United States in terms of number of vehicles, number of passengers carried, and route-miles. Despite continued interest and research in other operational methods, such as dial-a-ride, and in improved rail technologies and rail service expansion, conventional bus routes play a major role in moving people in cities. Opportunities exist for improving service and efficiency in such systems. Buses may lack glamour compared with other transit modes, but they nevertheless deserve further development and improvement as a vital aspect of public transportation.

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Some citations are no longer available from their original source. These citations are often available from th National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road,

Springfield, VA 22161. We have verified the order numbers for many of these citations, and they are found

at the end of the citation. Prices are available through NTIS at the address above.

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PERIODICALS

The following periodicals are suggested for those interested in the bus mode. They offer both historical information and current activities.

Bus Ride. Friendship Publications, Inc., Box 1472, Spokane, WA 99210 (eight issues per year).

Bus World. Magazine of Buses and Bus Systems, P.O. Box 39, Woodland Hills, CA (quarterly).

Mass Transit. Mass Transit, P.O. Box 1478, Riverton, NJ 08077 (nine issues per year).

Passenger Transport. American Public Transit Association, 1201 New York Ave., N.W., Washington, DC 20005 (weekly).

EXERCISES

6-1 Name five different types of bus route networks. Describe the circumstances under which each type would b most successful; least successful.

6-2 Obtain systemwide bus route maps for three different urban transit systems. Analyze the type or types o networks used by each system. It is possible that different network types may be used by different portions o the same system.

6-3 Discuss the advantages and disadvantages of using branches versus loops in bus routes.

6-4 Name three reasons for including layover or recovery time in bus schedules?

6-5 Obtain public timetables for six different bus routes. Indicate examples of (a) policy headways, (b) headway based on ridership demand, and (c) possible examples of branching or short-turning. Discuss whether th timetable is relatively easy to understand and whether some routing or scheduling changes might make th portion of the system more convenient or user friendly. What would be the cost or other trade-offs in makin such changes?

6-6 What are the advantages and disadvantages of a flat-fare system versus a zonefare system?

6-7 Review your city's subdivision or lot-platting regulations. Make suggestions for revisions that would make th design of future neighborhoods more convenient for laying out bus routes and for pedestrians to gain access t bus stops.

6-8 Determine the location of bus maintenance bases serving your local transit system. Suppose that an increase i the size of the bus fleet of 50% will need to be accommodated within 5 years to serve projected ridershi increases. Prepare an outline of the steps to be included in a technical study of whether it would be better t enlarge one or more existing maintenance bases or to establish one or more new ones and, if new ones, where?

6-9 You are at a public meeting representing your local transit system. During the question-and-answer session following your short talk, one person asks why your system does not purchase smaller, cheaper buses to run at midday, since he or she notices so many buses around town that are only half full. What is your reply to this question?

6-10 It has been determined to start a program of establishing park-and-ride lots to serve a fictitious bus-only transit system. Discuss the factors that should be considered in establishing the locations for these lots.